933-2.

LIGHTING DATA

EDISON LAMP WORKS
OF GENERAL ELECTRIC COMPANY

GENERAL SALES OFFICES HARRISON, N. J.

Automobile, Garage and Display Room Lighting

Information compiled by
L. C. PORTER (*Commercial Engineering Department*)
and
M. HORNER, Jr. (*Lighting Service Department*)

SYNOPSIS:

For information regarding MAZDA lamps and lighting questions, refer to the nearest sales office.

To insure receipt of bulletins, notify the Department of Publicity, Edison Lamp Works of General Electric Company, Harrison, N. J., of any change of address.

Automobile, Garage and Display Room Lighting

Information Compiled by
L. C. Porter, Commercial Engineering Department
and
M. Horner, Jr., Lighting Service Department

Introductory

The enormous growth of the automobile industry in this country, and the increasing popularity of night driving, have resulted, first, in State laws regulating the use of headlights and tail-lights, on motor cars, and second, in a demand for good lighting in the various garages, repair shops, auto supply depots, etc.

The growth in the number of dealers, garages and service stations is a part of thi remarkable advance. There are at present some 66,000 of these in the country. They vary from the modern establishment designed for the particular purpose of selling or maintaining motor cars, to the former livery stable or blacksmith shop which has been revamped to meet the requirements of the modern trend in vehicular transportation.

The increasing amount of night driving necessitates the operation of garages, repair shops, etc., after dark. Good lighting in these places will increase production and reduce accidents and spoilage. It has been proven many times that the cost of good lighting is but a very small percentage of the cost of the time, material and labor lost through poor lighting.

In many states adequate lighting is required by law in industrial plants, and the time may not be very far distant when this will apply to garages as well. Good lighting does not mean simply many, or large lamps. It means light scientifically applied, so as to be free from glare and deep shadows.

It is the purpose of this bulletin to point out how good lighting may be obtained and maintained on automobiles and in garages, auto supply houses and service stations.

Statistics show that twice the amount expended for the purchase of the car is spent on maintenance. When it is considered that about five billion dollars worth of automobile merchandise is being consumed annually, exclusive of oil and gasolene, the importance of the retail trade cannot be over-estimated.

The motorist is required by law to use headlights that provide a certain minimum amount of light on the road. This is for his own comfort and safety. He is also required to use headlights that do

not produce trying glare, which is so dangerous to an approaching driver. This is for the protection of the other fellow. Most drivers would desire to obtain these results, even were they not required by law. Few, however, understand the control of light. They expect to have the proper lighting equipment on their cars when they are purchased, and then they look to the garage or service station to keep the equipment in order. It is, therefore, the purpose of this bulletin to point out the various factors which enter into the proper adjustment and maintenance of the lighting equipment.

Automobiles

Headlamps—General

Lighting equipment today forms a very important part of every automobile. With the ever increasing average driving speed, the

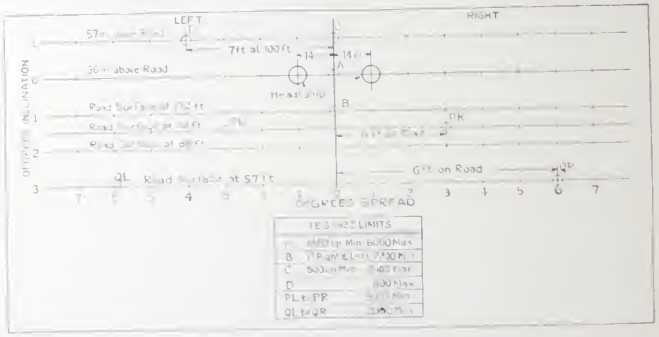

FIG. 1

Specifications for Motor Vehicle Headlight Beams as Drafted by the Illumination Engineering Society

congestion of our streets, and the great reliability of the car today, headlights must be provided that will illuminate the road for several hundred feet in front of the car, and which will not project glaring rays of light into the eyes of approaching drivers or pedestrians. The safety of the public on our highways at night depends to such an extent on the above requirements that practically all of the states in the Union, as well as the Dominion of Canada, have passed laws regulating and requiring the lighting of automobiles.

Unfortunately, these regulations vary somewhat in different states.* In general, this legislation takes the form of limiting the

* See *General Electric Review*, Feb., 1922, pages 120–124, for summary of all state laws and list of approved devices.

candle-power of the lamp that may be used in the headlight, in requiring headlight beams sufficiently powerful to pick up objects certain distances ahead of the car, and in requiring the use of some approved device which controls the distribution of the beam from the headlamps so as to prevent glare.

The Illuminating Engineering Society has done a great deal of research work along these lines, and has drawn up the foregoing specifications for headlight beams. These specifications have the backing of the Society of Automotive Engineers. Today, over 50 per cent of all the automobiles in the United States are operating in states which have based their regulatory headlight legislation on specifications prepared by the Illuminating Engineering Society.

In order to comply with these specifications, it is necessary to use high-class headlight lamps and equipment, and to have them

FIG. 2
The Foot-candle Meter, a Very Convenient Device for Checking the Distribution of the Headlight

carefully adjusted. Undoubtedly, the greatest difficulty from glaring lights and poor road illumination is due to improper adjustment of the equipment. The average car owner does not know how to adjust his headlamps, and most of those who know seldom do it. Many data have been printed on this subject, and detailed instructions for focusing are furnished by various state Departments of Motor Vehicles, as well as by lamp manufacturers.

In some cases it is desirable to measure the headlight beams to see if they comply with the state laws. Illumination tests used to be difficult to make, but today, by means of a simple little instrument, known as a foot-candle meter (Fig. 2), anyone can make his own measurements, and determine whether or not his headlamps

comply with the law. Simply hold the meter at the points and distances indicated in the diagram, Fig. 1, and multiply its reading (in foot-candles) by the square of the distance from the meter to the car, to obtain the candle-power of the beam at the point of measurement.

FIG. 3
21-candle-power MAZDA C Auto Headlamps
(A) Highly Concentrated. (B) Poor Concentration

There are also available guides issued by the lamp manufacturers which tell exactly what lamps to use for every make of car on the market. Suffice it to say here that it is of the utmost importance to use only lamps which are made with great accuracy and high filament concentration, such as the 21-candle-power, gas-filled MAZDA C lamp, Fig. 3-A. The candle-power maintenance of the gas-filled lamp is so much better than that of the MAZDA B, or vacuum, lamp that some states have even gone so far as to require by law the use of gas-filled lamps.

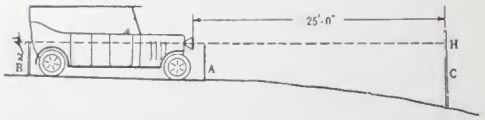

FIG. 4
Set-up for Adjustment of Headlamp Tilt

In addition to using the best lamps these must be focused very carefully. The following focusing instructions have been issued by the Headlight Committee of the Illuminating Engineering Society.

Adjustment of Tilt

Place the car fully loaded on a level surface, as, for instance, the floor of the garage (see accompanying Fig. 4). Measure the height

of the center of the headlamps from the floor, and cut off two sticks to a length equal to this height. Stand one of the sticks, A, near the front end of the car, and the other, B, near the rear. Arrange a board, C, so that it will stand on end, and set this up as a target at a distance of 25 feet ahead of the lamps so that the light of one headlamp or of both shines upon it. Remove the front glass from the lamp, or use only the plain glass, and operate the focusing adjustment (see below) so that the light forms a small patch on the target (Fig. 5). Sight over the top of the two vertical markers, A and B, on

FIG. 5
Appearance of Spot with Lamp at Focal Point

to the target, C, and place a line, H, at the point thus found. This will give the horizontal line. If the height of the center of the beam comes at the same height as this mark, the beam is horizontal. If the device which is to be used is one requiring a tilted beam, put another mark on the target at the requisite distance below the first mark. For instance, if a tilt of 2 feet in 100 is required, the target being 25 feet ahead of the lamps, the mark should be placed 6 inches below the horizontal mark. The headlamp is then tilted until the center of the beam comes at this lower mark with the car fully loaded. By shifting the target, the other lamp can be similarly adjusted. The actual tilting of the headlamps is a mechanical adjustment, which in some makes of cars is very simple, and in others requires some mechanical skill. See that the beams of both lamps point straight ahead. The horizontal distance between the centers of the beams should equal the distance between the centers of the headlamps.

Focus Adjustment

All, or nearly all, headlamps are provided with an arrangement whereby the position of the bulb may be changed with respect to the focal point of the parabolic mirror. This arrangement is sometimes a little difficult to find, but any owner, who is in trouble from this cause, may well consult a competent garage man. The adjustment of focus, as well as of tilt, can best be accomplished in moderate darkness. It will be found that taking the headlamps without any controlling devices whatever, and throwing the beams from each one separately on to the target, a more or less round spot, or patch of light is seen.

By operating the focusing adjustment the lamp is moved backward or forward with respect to the reflector. The following adjustments are recognized. Some devices require one of these adjustments, others another.

Adjustment No. 1

The center of the lamp filament is at the focus of the reflector. The patch of light made by the beam is then of minimum diameter.

Adjustment No. 2

The lamp is drawn backward from No. 1 adjustment. When this is done the patch of light becomes larger and finally a black spot appears at its center. When this spot is just on the point of appearing, adjustment No. 2 has been made.

Adjustment No. 3

The lamp position is intermediate between No. 1 and No. 2. The size of the patch of light is intermediate between No. 1 and No. 2.

Adjustment No. 4

The lamp is pushed forward from position No. 1 until a black spot is on the point of forming in the center of the patch of light.

In case the headlamp is so constructed that it is not easy to tell whether one is moving the lamp forward or backward, No. 2 can be distinguished from No. 4 by blowing a cloud of smoke into the beam directly in front of the headlamp. If the rays of light are seen to diverge as they leave the reflector, the adjustment is No. 2; if they converge and cross, it is No. 4.

In general, moving the light source either forward or backward along the axis of the reflector results in changing the spread of the beam. Moving the light source up from the axis throws the beam down; moving it downward throws the beam up. Moving to the right throws the beam to the left, and vice-versa, Fig. 6A.

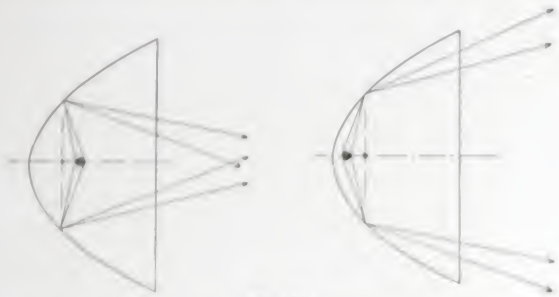

Fig. 6A
Action of Light Rays Originating from sources Located Respectively Ahead of and Behind the Focal Point in a Parabolic Reflector

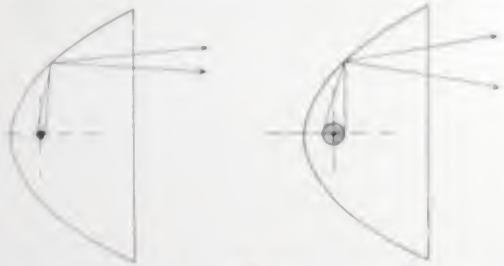

Fig. 6B
Effect on the Spread of the Beam of Large and Small Filaments

Be sure that the lamps are positively locked in position after the adjustment has been made. Some types of headlamps are so constructed that the focal adjustment is altered on replacing the front glass. With these headlamps the correctness of the adjustment can be judged by inspecting the patch of light thrown with the device in place. The top of this patch should be cut off more or less horizontally across the top, and the major portion of the patch should be below the horizontal line.

Beam Adjustment

Having secured the right tilt and focus adjustment, the controlling device which it is proposed to use is affixed to the headlamps, care being taken to see that it is placed exactly in accordance with the manufacturer's instructions, which should accompany the device.* The beam is then once more observed on the target to see whether the upper half of the beam is properly cut off and the light deflected toward the road, Fig. 7. In the case of many devices,

FIG. 7
Beam Deflected Toward the Road by Auxiliary Device

this cut-off is secured with the bulb at the reflector focus. In the case of some, however (those which obstruct the light from the upper part of the headlamp) the bulb must be brought back toward the reflector in order to secure the cut-off (Adjustment No. 2). With still others (those which obstruct the light from the lower half of the reflector) the bulb must be pushed forward ahead of the focus (Adjustment No. 4). In any case, a little experimenting will show what adjustment is necessary in order to secure the sharpest possible cut-off of the upper half of the beam.

Importance of Accuracy in Filament Construction

Tests have shown that if the filament of an automobile headlight lamp is located but $\frac{1}{16}$ in. away from the focal point of the reflector, the intensity of the beam will be reduced 70 per cent, with a corresponding loss in pick-up distance.

* When lamps of the 12–16-volt rating, or higher, are used, it may be necessary to tilt the headlamps slightly, after the lens has been applied, in order to prevent objectionable glare.

Lamp filaments which are not well concentrated and accurately located in the bulb cannot be focused to give a good concentrated beam. Fig. 6B shows the effect on the spread of the beam of large and small filaments. Fig. 8 shows the spot projected by automobile headlights (without lens) using the lamp shown in Fig. 3A. Fig. 9 shows the spot from the same reflector (without lens) using the less concentrated and less accurately located filament of the lamp shown in Fig. 3B. The lamps were operated at exactly the

FIG. 8
The Spot Projected by an Auto Headlamp without Lens Equipped with a 21-candle-power MAZDA C Lamp

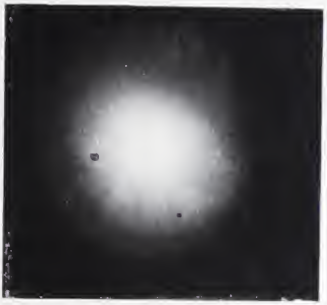

FIG. 9
The Spot Projected by the Same Device with a Lamp Having an Inaccurately Placed Filament

same candle-power (21), yet the beam candle-power in the former case was 98,000, and in the latter case 30,000. This, of course, has a great effect on the pick-up distance of the beam.

"Pick-up" Distance

The question is often asked as to what beam candle-power is necessary to pick up objects at various distances. There are many factors entering into the answer, such, for example, as the contrast between the object and its background; the relative rest or motion of the object and observer; the amount of extraneous light entering into the observer's eye from surrounding light sources, etc. The curves in Fig. 10 show the approximate beam candle-powers and pick-up distances for light, medium and dark colored objects seen against a dark background. Fig. 11 shows the braking distance required to stop cars traveling at different speeds and under various road conditions.* The beam from a pair of good headlights equipped

* *Ohio Motorist*, Feb., 1922, page 24.

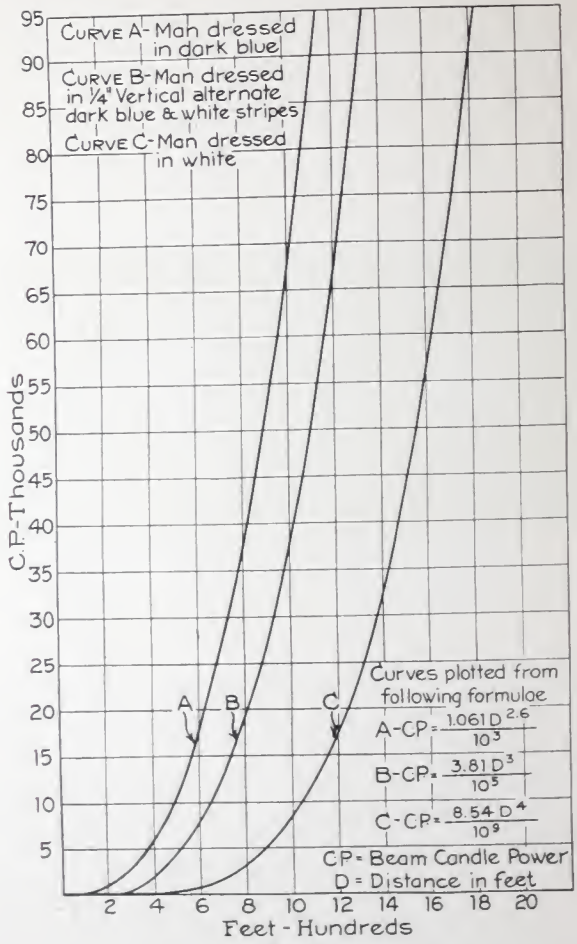

Fig. 10

Pick-up Distance for Various Conditions

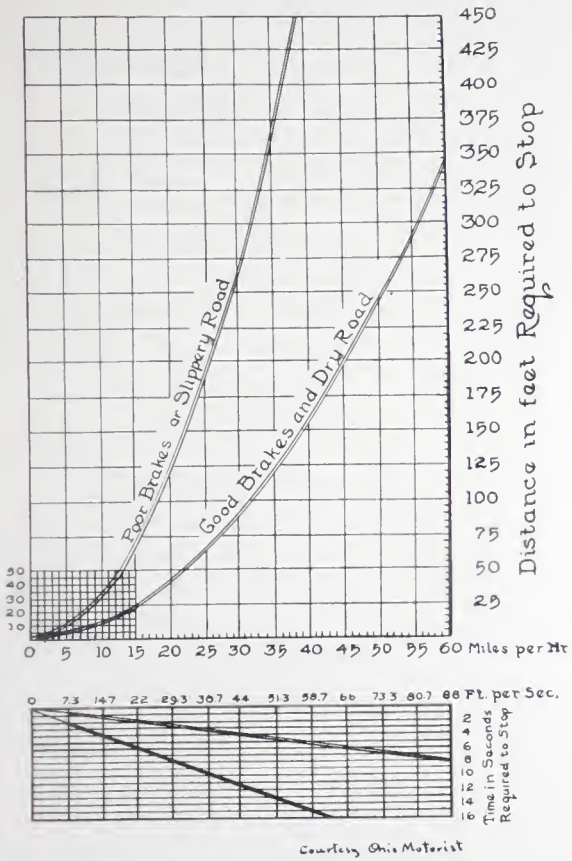

FIG. 11
Braking Distance for Various Conditions

with 21-candle-power MAZDA lamps, and approved glare-reducing lenses, will average about 20,000 candle-power, varying with the type of lenses used.

Rear Lamps

While headlamps are the most important lighting equipment on a motor car, they by no means complete the equipment.

The tail-light is also required by law, and, to best serve its purpose, must be a reliable lamp; one which will maintain its candle-power throughout life. The lamp must also be strong, as it is subject to no small amount of vibration. There is an increasing agitation to enforce the laws requiring the license plate to be legible certain minimum distances at night. This requires well designed tail-lights, and, on long license plates, possibly even the use of two lamps. The State of Massachusetts now requires the use of approved tail-lights, as well as approved headlights. Other states will, undoubtedly, follow suit.

"Stop" signals are coming rapidly into use on automobiles. These, to be effective, both by day and by night, should be equipped with a fairly high candle-power lamp. It is, therefore, recommended that 21-candle-power MAZDA C headlight lamps be used for this purpose. The weakest part of a "Stop" light is the switch. Care should be used in selecting only signals that have mechanically good switches, which will not jam or easily get out of order. There are several concerns building "Stop" lights having a lamp on the dashboard, burning in series with the lamp in the signal, to indicate whether or not the signal is working. These outfits usually require a special lamp, and for that reason are not very satisfactory.

There is one make of switch on the market which has two contacts. In closing the switch, a 2-candle-power lamp on the dash, in series with the signal lamp, is lighted and then shorted out as the 21-candle-power lamp in the signal lights up. The 2-candle-power lamp again flashes as the switch is opened, and the 21-candle-power lamp extinguished. This gives a positive indication each time the "Stop" signal lights, and again when it goes out, and has the advantage of allowing full voltage on the signal lamp, thus burning it at its full candle-power.

Standard Lamps

Only standard lamps, carried in stock by practically all garages, auto supply dealers, etc., all over the country, will give the greatest reliability and satisfaction. The following lamps are the types in most general use today and, therefore, the most likely to be found in stock:

Mazda Lamp Number		Volts	C-P.	Bulb	Base
61		3–4	2	G-6	Single contact—bayonet
63		6–8	2	G-6	Single contact—bayonet
67		12–16	2	G-6	Single contact—bayonet
1129		6–8	21	S-11	Single contact—bayonet
1130		6–8	21	S-11	Single contact—bayonet
1158	For Ford	6–8	21–3	S-11	Double contact—bayonet
1160	cars	9	21	S-11	Double contact—bayonet
1141		12–16	21	S-11	Single contact—bayonet

Lamps Nos. 61, 63 and 67 are used for the following service:

Sidelights
Tail-lights
Instrument lights
Trouble lights
Step lights
Auxiliary lights
Dome lights
Parking lights
Tonneau lights
Backing lights
Cowl lights

Lamps Nos. 1129, 1130, 1158, 1160 and 1141, are used for the following:

Headlights
Spotlights
Stop signals
Courtesy lights

There are some cars having special lamps: dome lamps, etc., but the tendency is strongly toward the use of standard lamps throughout, and of but two sizes, 21 candle-power and 2 candle-power. The cars formerly using 12–16-volt lighting systems are steadily coming over to 6–8-volt systems.

Maintenance of the Lighting Equipment

There are a surprising number of ways in which the lighting system of a car depreciates with service. By careful attention to these points, the lighting can be kept in good order.

Tests have shown that the contacts of the switches used in auto lighting circuits increase in resistance with age. This is due to wear, and the collection of dust and particles of insulating material worn off by the contactors, and imbedded in the contact studs. It has been found that this resistance will increase from about 0.015 ohms to twice that value. This would represent a material drop in the candle-power of the headlight lamps.

A little fine sandpaper rubbed over the contact points of the switches occasionally would reduce this loss.

Considerable resistance occurs at connections and fuse clips. These clips frequently corrode. This resistance is materially lowered by the use of link fuses fastened down under set screws. Where cartridge fuses are used, the contact ends, as well as the clips should be brightened occasionally with sandpaper. This may save an additional drop in candle-power of the lamps.

Even greater resistance with corresponding current drop occurs in the lamp sockets as they age. Cases have been found where the loss

in candle-power, due to socket resistance, ran as high as 50 per cent.

Sockets occasionally get loose or out of line, which makes it very difficult to focus the headlamps properly. Attention should occasionally be given to all joints, also to whether or not the plunger pins in the sockets work easily.

Another great cause of loss of light is due to dust and tarnish on the reflectors. An occasional rubbing up with chamois and some

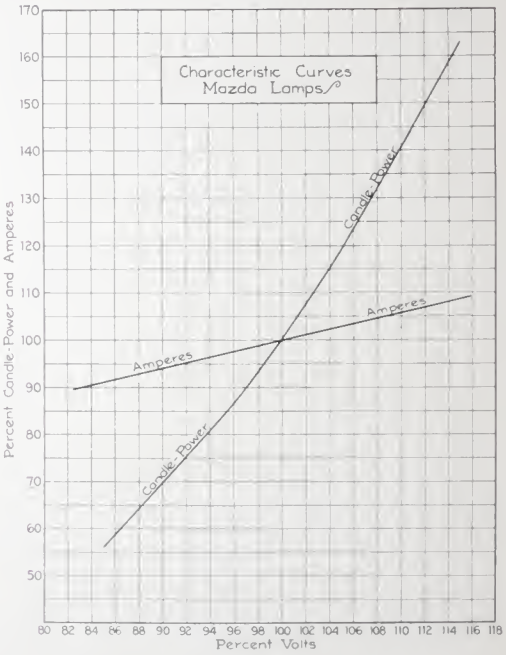

FIG. 12
Variation of Candle-power with Voltage

good silver polish will help materially to maintain the efficiency of the lighting. Such rubbing should only be done radially, *i.e.*, from the rim of the reflector in toward the center and out again. Never rub around the reflector as that would tend to produce ridges in positions such as to distort the beam. Great care should be used to

see that there are no dust particles or grit on the chamois or reflector, as these would scratch the surface. The polished surface should never be touched with the bare fingers, as they are always more or less moist and salty, and bound to leave a tarnish mark.

Some headlight lenses have a tendency to rotate in their rings. Care should be exercised to see that the prisms are vertical, otherwise they will deflect the light to undesirable points.

Blackened lamps should be destroyed and replaced by new ones.

The candle-power of an incandescent lamp varies rapidly with the applied voltage. See curve in Fig. 12.

When the battery on the car is partly discharged, the voltage will be low, with a corresponding drop in candle-power of the lamps. On the other hand, if excessive voltage is applied, as sometimes happens, particularly with Ford magnetos, short lamp life will result.

Fig. 13
Kit for Carrying Spare Lamps

All cars should carry a set of spare lamps, as it is impossible to predetermine just when a lamp will fail. Small lamp kits to facilitate carrying spare lamps are available, Fig. 13.

Private Garage

There is usually little provision made for lighting the private garage, outside of a drop cord and bare lamp. The slight added cost of installing efficient reflectors and lamps will be more than compensated for by the saving on clothes, time and temper, when making repairs.

A typical installation in a private garage is shown in Fig. 14. The portion to be well-lighted is that occupied by the forward end of the car where the motor is located. The ceiling outlet is accordingly placed so that it is centrally situated relative to a 10-foot square at that end. A 100-watt bowl enameled MAZDA lamp in this case 11 feet from the floor in an RLM standard dome reflector provides a good intensity for ordinary adjustment. A portable lamp may be plugged in on the side wall for work in positions more difficult to illuminate.

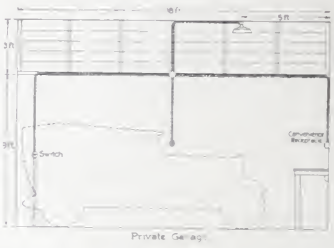

FIG. 14
Cross-section of a Typical Private Garage with Modern Lighting Installed

Garages

Main Floor

There is much room for improvement in lighting the main floor of the average public garage. In the majority of cases noted, the proprietor seems to consider it sufficient to hang up a few bare lamps. Very often these are of the larger size of MAZDA C lamps, and being hung at no great height, make the placing of a car in position a hazardous operation, due to the blinding effect of the glare, even though extremely low speed is maintained. Scratched and bent fenders and guards result from the crowded condition of most garages and the deep dark shadows which prevail.

Then, too, when work is to be performed on a car, usually in a position difficult to illuminate by direct rays, the mechanic must work in a shadow or carry about with him a portable lamp. The inefficiency and danger of local lighting for use in shops has been proven conclusively and one has but to look to the manufacturing end of the automobile industry to see demonstrated the efficiency and high speed production resulting from high intensity general lighting.

It is obvious, therefore, that the storing space in the garage should be uniformly illuminated to a moderate intensity, as indicated in Table 1. The lamps should be hung high, well out of view and equipped with reflectors to direct the light downward and at the same time protect the eye from the bright filament. The reflector chosen for this purpose should be efficient and of such a character that it will not depreciate in service.

TABLE 1

FOOT-CANDLES OF ILLUMINATION RECOMMENDED FOR VARIOUS PORTIONS OF THE SERVICE STATION

	Foot-candles Recommended	Possible Range
Garage, main floor	6	4–8
Machine shop	8	5–10
Show room	10	8–12
Dead storage	2	1–2
Office	10	6–12
Rest room	5	4–6
Store	6	4–8
Stock room	3	2–4
Wash room	4	3–6

The RLM standard dome reflector with the bowl enameled MAZDA C lamp forms a lighting unit which will serve very well for this purpose. If it is properly placed, dense shadows will be eliminated and glare avoided. The size of lamp and spacing of outlets will be governed by the ceiling height. For ceilings under 10 feet the spacing should not be greater than 12 or 15 feet. If the ceilings are 12 feet or more from the floor, spacings as high as 20 feet will be satisfactory.

The ceiling and side walls should be light in color. A flat or an eggshell white is desirable for the maximum efficiency of lighting. The lower part of the side walls, however, should be painted a dark green or similar neutral color in order to conceal finger marks and other disfigurements. In addition to actually increasing the useful light, white or lightly tinted side walls and ceilings are of much assistance in eliminating heavy shadows. Light is thrown on the objects from different angles after being reflected from the walls introducing diffusion which reduces shadows. More detailed information on this subject will be found in Bulletin Index 15.

The following table indicates the desirable size of lamps, and spacing of outlets for the various conditions likely to be encountered in the storage space. This is based on the use of bowl enameled MAZDA C lamps and RLM Standard Dome Reflectors.

Ceiling Height	LIGHT SURROUNDINGS		DARK SURROUNDINGS	
	Size Lamp	Spacing	Size Lamp	Spacing
9–11 feet	75-watt	12 ft. by 12 ft.	100-watt	12 ft. by 12 ft.
12–15 feet	150-watt	20 ft. by 20 ft.	200-watt	18 ft. by 18 ft.
Over 15 feet	200-watt	25 ft. by 25 ft.	200-watt	20 ft. by 20 ft.

A layout based on this tabulation is pictured in Fig. 15. In this instance there will be noted a large machine shop adjoining the garage and hence comparatively little work will be done on the main floor. Under such conditions the minimum values of recommended foot-candle intensities may be employed. These allow for the ordinary inspections to be made and cars accurately placed without danger of injury. Where considerable work is carried on in the storage space, higher values of illumination are recommended.

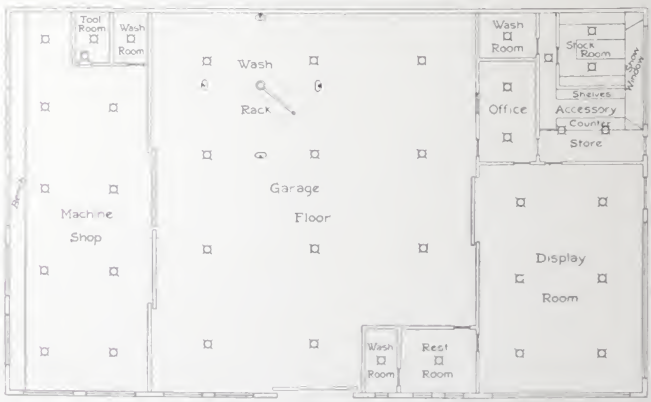

FIG. 15

Layout of Service Station Showing Lighting Arrangement. The following data apply: *Main Floor.*—200-watt bowl enameled MAZDA C lamps, RLM standard dome reflectors, spaced 15 by 17 feet. Four foot-candles effective. *Machine Shop.*—Same unit spaced 11 by 13 feet. Nine to ten foot-candles effective. *Display Room.*—300-watt clear MAZDA C lamps in enclosing diffusing globes spaced 12 by 13 feet. Ten to twelve foot-candles effective. *Accessory Store and Office.*—200-watt clear MAZDA C lamps in light-directing enclosing globes arranged to give ten to twelve foot-candles. *Rest Room.*—200-watt clear MAZDA C lamp in decorative, semi-indirect unit. *Stock and Tool Rooms.*—50-watt clear MAZDA B lamps in distributing type steel reflectors. *Wash Room.*—50-watt clear MAZDA B lamps in deep bowl opalescent glass reflectors.

Convenient outlets should always be provided on the posts or side walls. To these, portable lamps, electric drills and similar tools may be connected, making it unnecessary to move the cars for

detailed inspection or to effect minor repairs. These outlets should be of a sturdy type and located in such position that they will not be damaged.

A night view of a storage garage illuminated in accordance with the outline above given will be seen in Fig. 16. It is of interest to note the effectiveness of the surroundings in diffusing the light.

FIG. 16.
Night View of Modern Garage Lighted by 200-watt Bowl Enameled Mazda C Lamps in RLM Standard Dome Reflectors, one per 200 sq. ft., hung close to the 15-ft. ceiling.

Wash Rack

Special attention should be paid to the lighting of that portion of the floor where cars are washed. A car can be cleaned better and more quickly if sufficient light is provided to enable the cleaner to see the car easily.

FIG. 17.
Arrangement of Lighting Units at the Wash Rack.

It is difficult to produce a high degree of illumination on the vertical sides of the car from an overhead source having a symmetrical distribution. It is also obvious that floodlights projecting the light horizontally would produce a condition of glare which would be objectionable on a garage floor.

An arrangement of angle reflectors is shown in Fig. 17 which will effectively illuminate the sides of the car to a suitable intensity. Porcelain enameled elliptical reflectors are used in this instance, suspended 12 feet from the floor and furnished with 200-watt MAZDA C lamps.

A switch should be arranged to control these lamps so that they may be turned off when not in use.

Machine Shop

In the machine shop, where major repairs are effected, the very best lighting obtainable should be provided. High intensity illumination of the proper character in this part of the industry will have a marked effect on the speed of production and quality of work produced.

The repair job is a very intimate point of contact between the automobile industry and the general public. The honest garage owner has no desire to charge the customer an abnormally high price for a given piece of work. A reasonable charge on such a job produces a satisfied customer and secures his future business. Inasmuch as the charge is based on the time expended, lighting has a very direct effect on this.

There is no question in the minds of those who have investigated the subject but that with proper illumination the time required to do a given piece of work is materially reduced. With high level lighting no time is lost looking around for a tool which has fallen, neither does the workman have to strain his eyes to follow the details of the work. This subject is too extensive to warrant devoting more space at this place and the reader is urged to refer to Bulletin Index 11, entitled, "Light and Production."

The machine tool must receive light of the proper intensity from the correct direction if the best results are to be obtained. A separate bulletin, Index 62, "The Lighting of Machine Shops," covers this question in detail. A typical layout is pictured in Fig. 15. In general from 1 to 1.5 watts per square foot of floor area should be provided with bowl enameled MAZDA C lamps and RLM Standard Dome Reflectors.

Stock and Tool Rooms

A comparatively high intensity is required in the tool room where gauges are checked, micrometers employed and careful inspection of tools and jigs is made.

General illumination for the room as a whole can well be supplemented by localized lighting at the counter. Standard types of industrial equipment are suitable for this.

In the stock room, the bins and racks frequently reach to the ceiling with narrow aisles between rows. Lighting must be provided over the face of the bins to read labels and make it possible

FIG. 18

A Ladies' Rest Room in an Up-to-date Garage. General illumination is provided by the semi-indirect system and supplemented by decorative table lamps which harmonize with the cretonne hangings

to locate a desired part at once. A 50-watt MAZDA lamp in a distributing type (shallow) porcelain enameled steel reflector is satisfactory for this lighting. Outlets on centers from 8 to 10 feet should be provided, the exact locations depending on the arrangement of the aisles. The reflector should be approximately level with the top of the shelf.

Rest Room

The modern garage has found it profitable to provide a rest or waiting room for the comfort of its patrons and tourists. Such a

room extends an invitation especially to the women of the party to take advantage of its comfort when making a stop.

The decorative features of lighting are more important in this room than in other portions of the garage and the soft, even illumination produced by the semi-indirect system is in good taste. A table lamp of decorative design adds to the general coziness of the room. The lighting should be planned to augment the neatness and attractiveness which are so essential in the rest room. A room such as pictured in Fig. 18 will do much to add to the popularity of the establishment. Industrial or commercial forms of lighting units are quite out of place here.

Office

Enclosing units with clear MAZDA C lamps are rapidly coming into favor for office lighting, since they combine the efficiency of directing devices with diffusing properties as well as keeping dirt and dust from the lamp bulbs. From $1\frac{1}{2}$ to 2 watts per square foot of floor area should be provided in the office. A typical layout of a small office is indicated in the plan Fig. 15. Convenient outlets for fans, dictaphones and other electrically operated office devices should be provided.

Accessory Store

Proper illumination is necessary in the store. It is here that the customer and the merchant meet and the sale is to be made. A well-lighted store invites the attention of the passerby and causes him instinctively to reflect upon the necessity of purchase in that line. If the shop is attractive the customer can be more easily held and the probability of further sales increased.

A recent investigation showed that, in two-thirds of the stores of this type inspected, enclosing glass units were used. This tendency is sound since a unit of this sort, while amply lighting the counter, will provide illumination for the shelves, racks and side walls without the presence of glare. For a store similar in plan to that indicated in Fig. 15 two enclosing units over the counter at a height of 10 feet and spaced as shown will give an average illumination of about 8 foot-candles when 150-watt clear MAZDA C lamps are used. Using from 1.4 to 2.2 watts per square foot of floor area an illumination within the specified range will result. Bulletin Index 33, "The Lighting of Small Stores," will be of interest to those who desire to increase the attractiveness of the accessory store by the use of artificial light.

Garage and accessory stores are very often equipped with large show windows, which give them a unique opportunity of silently, yet forcibly, suggesting to the motorist the purchase of equipment for his car. The methods in use for lighting for display purposes are taken up later under Display Room Show Windows. Particular attention should be paid to the possibilities of spotlighting in the case of large windows which provide for the easy concealment of the light sources.

Display Room

Automobile display rooms are usually located in districts where rental charges are high. The prominent location is counted on to compensate for the added cost, by the additional sales brought in. Every advantage of the situation, therefore, must be utilized in order that the returns may justify the large overhead expenses.

To accomplish this, the exhibit must be effective over the greatest possible period of the day. Night time, also, should increase, rather than lessen, the value of the display, because of the natural contrast of the lighted window with the darkness outside.

At the present stage of automobile development, appearance has much to do with the popularity of the car, and accordingly a great deal of time and energy is expended in making it attractive.

A display room, by its very name, indicates that objects placed therein are to be seen. To be seen at all, they must be illuminated; to be seen properly, they must be lighted in such a manner as to stand out in their true proportions of color and contour.

Good lighting may lift the ordinary display out of the commonplace and make it effective. Without it, no exhibit can make its best appeal. Because of its easy control and flexibility, it is a pliable means of securing attention-compelling effects. The ability of focusing attention on one or more particular points, without detracting from the general exhibit, is especially advantageous in automobile displays.

We come, therefore, to the methods of employing illumination to accomplish these aims. How may it be utilized? Primarily, by the volume of light itself. It will be conceded that a high intensity of illumination compels attention. This is true psychologically, for a bright light symbolizes awakened interest, it is a stimulus for greater mental activity. A bright spot in the field of view will cause the eye to turn toward it instinctively.

The second idea in the use of light is the ability to flood the individual portions of the exhibit with a still higher intensity of

light. The attention which has been drawn to the display as a whole may thereby be focused upon the particular part with which it is desired to impress the observer.

The third feature is the use of colored light. This idea, originally a novelty of seemingly little importance, has recently made such strides as to become an absolute necessity in up-to-date display lighting. Painting with light, as it has been aptly described, will be taken up in more detail later on.

It has come to be recognized that more light in any salesroom means more sales. The psychological effect of low intensity is to produce a condition of lethargy, both in the customer and in the salesman. A higher intensity of illumination, however, quickens the sensibilities of the customer and causes him to arrive at a decision more quickly. The energy and aggressiveness of the salesman have likewise been considerably increased.

Having decided upon the intensity of illumination, which should be within the range indicated in Table 1, it is next in order to choose the general type of fixture or luminaire, as it is now called, to produce that intensity. One point which must be considered when selecting the type is that the polished surfaces of the objects displayed are likely to give back a specular reflection, *i.e.*, the image of the light source itself. The choice is therefore limited to systems where the filament of the lamp is concealed from view.

A dignified effect may be obtained by the use of totally indirect units. Such devices project all of the light upward toward the ceiling from whence it is reflected downward—no light sources are visible. Totally indirect fixtures may be suspended from the ceiling, mounted in side wall boxes, or at the top of ornamental pedestals. An example of the use of such a unit is shown in Fig. 19. Another form of totally indirect lighting employs what is known as a cove. A recess is constructed in the wall near the ceiling and lamps and reflectors are placed within this, entirely concealed from view. Totally indirect lighting produces excellent diffusion, and eliminates sharp shadows and the possibility of glaring reflections from polished surfaces. The sensation experienced on entering a room lighted in this manner is pleasing, the even, soft yet sufficient illumination harmonizing with the quiet richness of the surroundings. With totally indirect lighting, from 2 to 2.5 watts per square foot of floor area should be provided to obtain the recommended intensity for this class of service.

Semi-indirect lighting is similar to totally indirect, save that the reflector itself is translucent, transmitting some of the light and rendering the bowl or fixture luminous. Most of the light is projected toward the ceiling and as before a soft, diffused illumination is produced. The units are available in many decorative styles and may be ornamented by metal bands and other decorative elements.

FIG. 19

A Display as it Appears with Totally Indirect Illumination. Mirrored reflectors and MAZDA C lamps are concealed within the ornamental casings at the top of the pedestals. No ceiling fixtures are necessary when such an arrangement is employed

Light colored surroundings are, of course, essential with any indirect system and if these are available the required intensity may be obtained by semi-indirect units equipped with the proper size of lamps to give from 1.6 to 2.2 watts per square foot of floor area.

Where direct lighting is employed the high wattage MAZDA C lamp should be enclosed in some sort of diffusing globe. Many designs of enclosing globes are available, some so arranged as to have a light directing as well as a diffusing effect, emitting a larger

proportion of the light below the horizontal with correspondingly less illumination on the side walls and ceiling. A unit of these general characteristics should be chosen where dark surroundings prevail.

There is practically no limit to the decorative effects which may be produced by enclosing globes. Many sizes and types are now standard on the market. One rather important point to keep in mind is the relation of the contour of the fixture to the dimensions of the room. While the squat or flat type of globe gives a higher utilization of light, in many display rooms the ceiling is relatively high and the room comparatively narrow. Here a longer, pointed or stalactite shape globe presents a better appearance and is, therefore, to be preferred. Where enclosing globe units are used in the display room, from 1.5 to 2.0 watts per square foot of floor area should be provided.

Cleaning the bowls, reflectors and globes at regular intervals is of utmost importance. An interesting table showing the effect on the illumination produced by allowing the reflecting equipment to remain uncleaned is shown. These figures, based on average office conditions in an industrial city, show the divergence between indirect and enclosing units.

Approximate loss in percentage of initial illumination on working plane:

	4 Weeks	8 Weeks	12 Weeks	16 Weeks
Enclosing globes	9	13	17	20
Semi-indirect	14	22	29	35
Totally indirect	20	29	37	44

The proximity of the display room to the street usually results in the rapid accumulation of dust particles and the resultant cutting down of the light within a short period. The very design of the parts in the indirect systems makes the accumulation greater and, since the dirt gathers on the inner surfaces where it is not readily seen, the condition is not noticeable until the illumination drops far below that intensity for which it was designed.

Show Window

As has often been said, a show window is a stage upon which the display man arranges his exhibits to attract the attention of the public. It, therefore, follows that the aids and devices employed by the stage manager may be copied and used advantageously by him. The first idea is to produce sufficient intensity of illumination to make the window stand out as a brightly lighted spot among the others on the street.

In order to utilize all of the light possible by throwing it upon the display instead of allowing it to light up the ceiling or escape into the street, an efficient reflector must be used. There are many types of reflectors of various sizes and shapes, which will give the correct distribution of light for any given application. The typical show window reflector, known as the angle type, sends the light down and toward the rear. By using a number of these reflectors close together with the proper size lamps, an even distribution of light of high intensity may be obtained.

It is often desirable to point out one or more particular features of the display without necessarily subordinating the remainder. This may be accomplished by projecting upon such portions a beam of light of still higher intensity. Spot lights, such as used on the stage, have been adapted for this service. Several types are shown in Bulletin Index 31, as are also various types of modern window lighting reflectors.

While it is not possible to produce as striking an effect in individual display lighting on an open floor as it is in a show window, yet these same devices, with modifications, may be used to advantage.

In the case of a car displayed on the floor, the person interested will naturally wish to view it from all angles. Consequently, it is objectionable to have an unscreened light source visible. Angle reflectors at the ceiling must be used, and, because of the extreme height the lamp must be large. Further, to avoid specular reflection and any manifestation of glare, diffusing screens over the mouth of the reflector should be employed. By this method a flood of strong, diffused light may be made to envelop the exhibit. To this may be added a spot light suitably placed to bring out some new features of interest.

Rapid strides have been made of late in the application of colored light for display purposes. At the same time, the use of daylight lamps has been found to be of enormous value. The ability to show the manner in which the car appears in the day time is of utmost importance, as it is then that the car will receive the major portion of its attention. With the present day inclination toward bright colors it is desirable that the illumination bring out these colors in their true value. For instance, a car painted a bright blue when viewed under a light having a preponderance of red will appear as a dull, lifeless black; if the yellow portion is strong the color will resemble a dirty green. Daylight MAZDA lamps produce

illumination which is a close approximation to daylight in color value and will be found of use for this class of display lighting.

On the other hand, it may be advantageous to employ a light which will strengthen or accentuate the original color and give it life. For example, if the car first mentioned were flooded with blue light, it would stand out in all of its true beauty and brilliancy of color.

FIG. 20
A Garage Well-advertised Through Floodlighting Applied to Its Exterior

There are several devices for producing colored light easily, one of the latest being the use of colored glass globes which are placed over the lamps in the reflector. As they are easily attached and removed, it is only the work of a moment to change the illumination from one color to another. Another device employs gelatin screens which clip over the mouth of the reflector, and which also may be readily removed. These devices are also shown in Bulletin Index 31 in connection with the angle reflectors. It should be borne in mind that considerably more wattage must be employed when using color devices to produce the intensity equivalent to that without them. The values of such an increase depend on the color used.

From an artistic viewpoint, the attractiveness of a display room may be enhanced by the addition of floor lamps and torchiers. The lamps used in them should be of just sufficient size pleasingly to illuminate the shade and stand. These units should not be counted on to supplement the general illumination, but are to be used for decorative purposes only.

Exterior

The external appearance of a garage or service station very often suggests to the mind of the motorist the kind of service he will obtain within. It is, therefore, essential that the proprietor do

everything possible to make the exterior of his establishment appear attractive.

Flood lighting the face of the building by means of projectors mounted either on the building or adjacent thereto has been found very satisfactory. Such a system makes the building stand out and typifies to the motorist the idea of an up-to-date garage (note Figs. 20 and 21).

FIG. 21

A Filling Station Need Not be an Eyesore to the Community. The proper design supplemented by modern lighting skillfully utilized makes it an asset to the community. Here ornamental standards light the surrounding area, while lamps concealed beneath the eaves render the building luminous

Bulletin Index 95 on Flood Lighting and Index 92 on Sign Lighting give detailed instructions and the underlying theory in connection with this type of illumination which will be found very interesting and instructive.

Bibliography

Headlights

"Automobile Headlighting Report, Committee on Glare," Transactions, I.E.S., Vol. XI, page 29.

"A Survey of the Automobile Headlamp Situation," W. F. Little, Transactions, I.E.S., Vol. XII, page 123.

"Present Practice in Automobile Headlighting," S. C. Rogers, Transactions, I.E.S., Vol. XII, page 158.

"Road Illumination by means of Automobile Headlamps," H. P. Gage, Transactions, I.E.S., Vol. XII, page 179.

"Automobile Headlamps," E. J. Edwards, Transactions, I.E.S., Vol. XII, page 172.

"The Headlamp Glare Problem," J. R. Cravath, Transactions, I.E.S., Vol. XII, page 188.

"Report of the 1916-17 Committee on Automobile Headlamps," Transactions, I.E.S., Vol. XIII, page 259.

"The Automobile Headlighting Problem Again," E. J. Edwards, *General Electric Review*, September, 1917.

"Automobile Headlights and Glare Reducing Devices," L. C. Porter, *General Electric Review*, September, 1918.

"The New York State Automobile Headlight Law," F. M. Hugo, Transactions, I.E.S., Vol. XIV, page 61.

"Report of 1917-18 Committee on Automobile Headlighting Specifications," Transactions, I.E.S., Vol. XIV, page 64.

"Proposed Regulations for Incorporation in Model Law in Regard to Headlamps on Motor Vehicles," L. B. Marks, Transactions, I.E.S., Vol. XIV, page 100.

"Report of Committee on Automobile Headlighting Specifications, 1918-19," Transactions, I.E.S., Vol. XIV, page 500.

"Foot-candle Meter used to Measure Glaring Headlights," *Motor Life*, January, 1920.

"Connecticut Headlight Law and Method of Enforcement," *Automobile Topics*," January 17, 1920.

"Improved Mazda Automobile Headlight Lamps," L. C. Porter, *General Electric Review*, January, 1920.

"Motor Car Headlights and Rear Lights in Relation to Traffic Requirements," J. W. T. Walsh, *Illuminating Engineer* (British) April, 1920.

"A Survey of Voltage Conditions in Automobile Lighting," H. H. Magdsick and H. Karg, Transactions, I.E.S., Vol. XV, page 519.

"Motor Car Headlights—Ideal Requirements and Practical Solution," M. A. Garrard, *Illuminating Engineer* (British) April, 1921.

"Present Status of Automobile Headlighting Regulation, 1920-21," Transactions, I.E.S., Vol. XVI, page 469.

"Determination by Various Observers of the Desired Road Illumination from Automobile Headlamps," H. H. Magdsick and R. N. Falge, Transactions, I.E.S., Vol. XVI, page 480.

"Motor Vehicle Headlights in Massachusetts," A. W. Devine, Transactions, I.E.S., Vol. XVI, page 507.

"Sizes of Auto Headlights on 1915-21 Cars," *Motor Record*, December, 1921.

"Automobile Headlight Regulation," L. C. Porter and R. W. Jordan, *General Electric Review*, February, 1922.

"Interim Report of Committee on Motor Vehicle Lighting," Transactions, I.E.S., Vol. XVII, page 103.

"Lighting Division Report, Standards Committee S.A.E.," *Journal S.A.E.*, August, 1922.

"State Regulation of Motor Car Headlamps," *Journal A.I.E.E.*, March, 1922.

Automobile Factory

"Lighting of Automobile Factories," C. E. Clewell, *Electrical World*, June 30, 1917.

"Improved Lighting of Automobile Manufacturing Plants," F. H. Bernhard. *Electrical Review*, August 10, 1918.

"Lighting in Modern Automobile Factory," *Electrical World*, October 16, 1920.

"Illumination of a Modern Motor Truck Plant," W. A. Scott, *Electrical Review*, June 11, 1921.